Soybeans

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T. E. NICHOLS, JR.
JOHN G. CLAPP, JR.
RICHARD K. PERRIN

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ABSTRACT

The purpose of this study was to isolate and measure the effects of factors associated with variation in content of oil and protein of soybeans grown in North Carolina. Factors considered included varieties, lime and fertilizer applications, planting dates, soil conditions, seed treatments, herbicide application, and cultural practices. Data from 33 experiments on co-operator farms in Eastern and Piedmont counties were used in the analysis. Replications were pooled and ordinary least squares regression techniques were used to estimate the relationships between explanatory variables representing these factors and average oil and protein content of the beans.

The study indicated that soil characteristics, varieties and cultural practices do have an effect on the oil and protein content of soybeans. It was found that two tons of lime per acre increased protein content on the average of 5 percent, decreased oil content by 3.5 percent and increased yields by 7 bushels.

A number of factors such as seeding rate, seed size, row width, and herbicide treatment were found not to be associated with oil and protein content.

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T. E. Nichols, Jr., John G. Clapp, Jr., and Richard K. Perrin[a]

Introduction

The oil and meal content of soybeans influences the value of production obtained from soybeans and, hence, the price paid for the beans. Soybeans vary in oil and protein content from one region to another and even from farm to farm. In general, soybeans having a high percentage of protein will have a low percentage of oil, and vice versa.

Oil content of soybeans shows a general tendency to increase from north to south, and protein content generally decreases from north to south. While oil content is highest for soybeans grown in the south, the north central states have higher seed yield and oil yield per acre.

The amount of meal obtained from processing a bushel of soybeans far exceeds the amount of oil--about 4 1/2 times as much (roughly 47.5 pounds of meal to 10.8 pounds of oil). Oil is more valuable than meal on a per pound basis and prior to the 1960's the oil in soybeans was more valuable than the meal. Since the 1960's, meal has represented about 60 percent of the total product value and oil about 40 percent.

The Problem

Until recently processors have not discriminated among regions in pricing soybeans with different protein and oil contents. Instead,

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[a]Extension Professor, Department of Economics and Business, formerly Extension Associate Professor, Department of Crop Science and presently Scientific Agronomist, Allied Chemical Corp., and Associate Professor, Department of Economics and Business, respectively.

they have priced beans from a given area based on an average oil and protein content. Thus, producers with beans that contained a significantly higher oil or protein content were penalized relative to those producing a lower oil and protein level.

Currently oil and protein content is not one of the factors used in determining grade or quality of beans based on U. S. standards. Consequently, the producer has concentrated more on growing varieties with high yields per acre than those with high oil or high protein contents. A practical method of measuring the protein and oil content of soybeans at time of sale, however, is now available through the use of infrared spectrophotometers produced by at least two commercial instrument makers. Thus, it is possible to price soybeans at the producer level based on their oil and protein content.

Presently, there is very little known of the effects of soil characteristics, varieties and cultural practices on oil and protein content. More information is needed to determine the biological factors which determine the protein and oil content of beans. Once these relationships are known, recommendations can be made to producers to correct any deficiencies which may exist. Also, a more equitable procedure for pricing raw beans must be devised. Only then will producers get full return from their production and marketing efforts.

Objectives

The major purpose of this study was to determine what factors affect the oil and protein content of soybeans grown in North Carolina. In the analysis, emphasis was placed on those factors which can be readily related to management practices under the control of the producer.

Specifically, the objectives were:

1. To isolate and measure the effects of factors associated with the oil and protein of soybeans;

2. To assess the implications of the results for North Carolina soybean producers.

Procedures

Experimental Procedure

Various controlled experiments were conducted in 1973 on 33 cooperator farms located in 33 Coastal and Piedmont counties of North Carolina. Varieties were grown in four replicated plots at each farm location. These plots, consisting of four 100 feet rows, were grown using recommended cultural practices. Only the two center rows were harvested for a distance of 98 feet. Where applicable, soil tests and nematode assays were made prior to planting to determine necessary fertilizer and nematicide treatments.

Each plot was harvested and tested in a uniform manner. Approximately 1100 samples of beans were evaluated using an infrared spectrophotometer for quick determination of moisture, oil, and protein.[1]

Analytical Procedure

Each experiment was designed so that statistical techniques could be used to analyze and test the pertinent sources of variation. To increase the number of observations on the effect of any one factor, plot means were pooled across locations and least squares regression techniques were used. The pooling technique sometimes revealed relationships which were not evident from the examination of results from any one location.

Study Results

Area Effect

While there were observed differences in the average oil and protein content of beans between areas within the state, these were not statistically significant (Table 1). Beans grown in the Coastal Plains had 3.05 percent more protein than did beans produced in the Piedmont in 1973. The Piedmont beans had slightly more oil, 1.61 percent, than did the Coastal Plains beans. These averages ran

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[1]These tests were conducted on a Grain Quality Analyzer, manufactured by Neotec Instruments, Inc., Rockville, Maryland. Use of this equipment implies no endorsement by the University.

slightly higher but in the same direction as tests conducted on a smaller sample of soybeans in 1972.

Table 1 Average protein and oil content of soybeans from 33 experimental locations in North Carolina Coastal Plains and Piedmont, 1973.

Area	Number of Observations	Number of Locations	Average Protein Content	Standard Deviation	Average Oil Content	Standard Deviation
			(percent)	(percent)	(percent)	(percent)
Coastal Plains	856	26	40.96	1.85	23.79	3.56
Piedmont	225	7	37.92	2.07	25.40	2.40

Varieties

Variety effects on oil and protein content of soybeans were quite significant as shown by the data in Table 2 and also represented in Figure 1. The results from seven variety experimental locations (Table 2) were very close to the results from pooled data on varieties at all 33 locations (Figure 1).

One can observe from the scatter of observations in Figure 1 that, in general, an increase of 1 percent in protein content of beans can be achieved at the expense of a 1 percent reduction in oil content.

Fertilizer Practices

Fertilizer practices were explicitly considered as treatments at 13 locations. The addition of lime clearly results in an increase in protein content and a decrease in oil content. The estimated relationships between oil and protein content and liming are shown in Figures 2 and 3. In the experiments on three locations in which lime was a treatment variable liming acid soils, according to soil test suggestions, appears to increase protein content by as much as 5 percent and decrease oil by up to 3 1/2 percent.[1] Maximum effect on both

[1]Application of lime varied from 0 to 3 tons per acre. The following equations were derived for protein and oil: $P = 37.34 + 4.94L^{**} - 1.14L^{2**}$; $O = 26.97 - 3.34L^{**} + 0.79L^{2**}$ (** significant at 1 percent level).

Table 2 Estimates of departures from the average oil and protein content, estimated from results at seven variety experimental locations in the North Carolina Coastal Plains and Piedmont, 1973.

Variety Number	Name	Oil Content (percent)	Protein Content (percent)
(4)	York	2.18*	-1.84*
(11)	Coker Hampton 266A	2.14*	-2.05*
(5)	Coker 69-87A	1.48*	-1.01*
(20)	Ransom	1.17	-1.32
(1)	Dare	.72	- .02
(24)	FFR 07541034	.67	- .54
(17)	McNair 600	.53	-1.30
(9)	FFR 953318	.49	.41
(29)	N69-5033	.39	- .72
(27)	N70-2151	.33	- .16
(8)	FFR 953284	.32	.48
(28)	N70-2173	.13	- .68
(3)	Forrest	.12	.53
(12)	Davis	.10	.69
(19)	Picket 71	.11	- .32
(22)	Coker 71-211	.11	- .72
(16)	Lee 68	.21	.60
(6)	Coker 70-136	- .26	.72
(26)	N70-1619	- .31	- .24
(14)	FFR 777	- .35	- .48
(7)	Coker 70-137	- .50	.04
(13)	FFR 666	- .53	.80
(21)	Coker 68-38	- .55	.50
(2)	Essex	- .72	.18
(10)	Bragg	- .83	.39
(18)	McNair 800	- .95	.32
(23)	Coker 71-222	-1.09	1.20
(15)	Hutton	-1.17	1.72*
(30)	Ark-R-69-1400	-1.25	2.90*
(25)	D67-4601	-1.75*	1.56*
Average of all		24.04	40.09

*Significantly different from average at the 5 percent level.

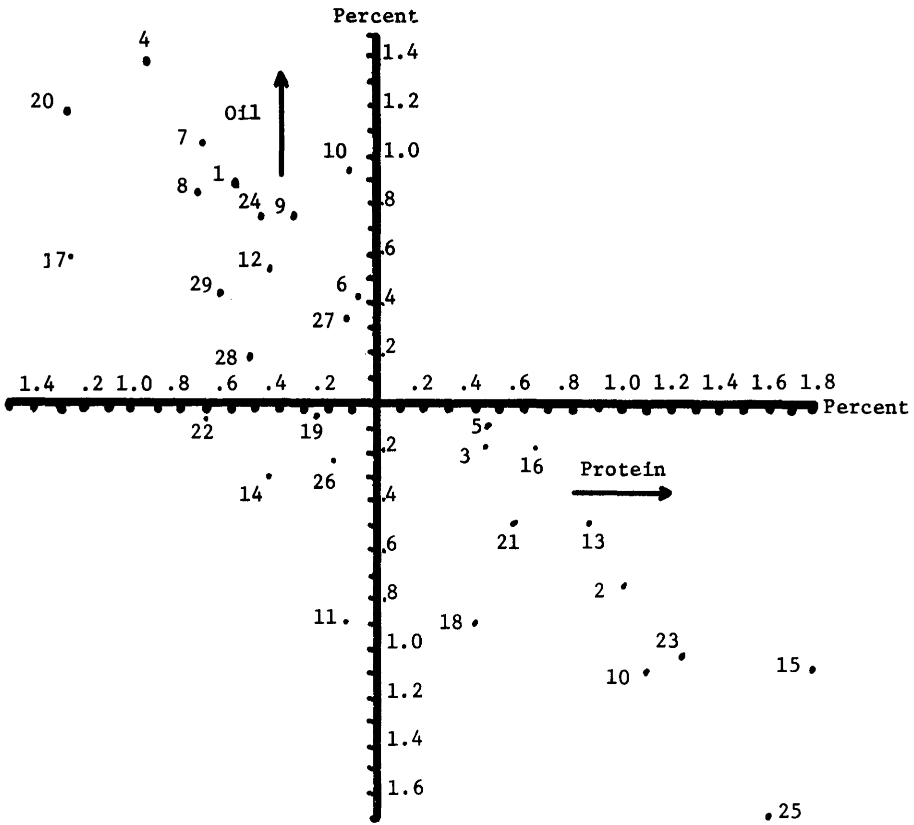

Figure 1. Varietal deviations from average oil and protein content of soybean, estimated from pooled data at 33 locations in N. C. (varieties numbered as in Table 2)

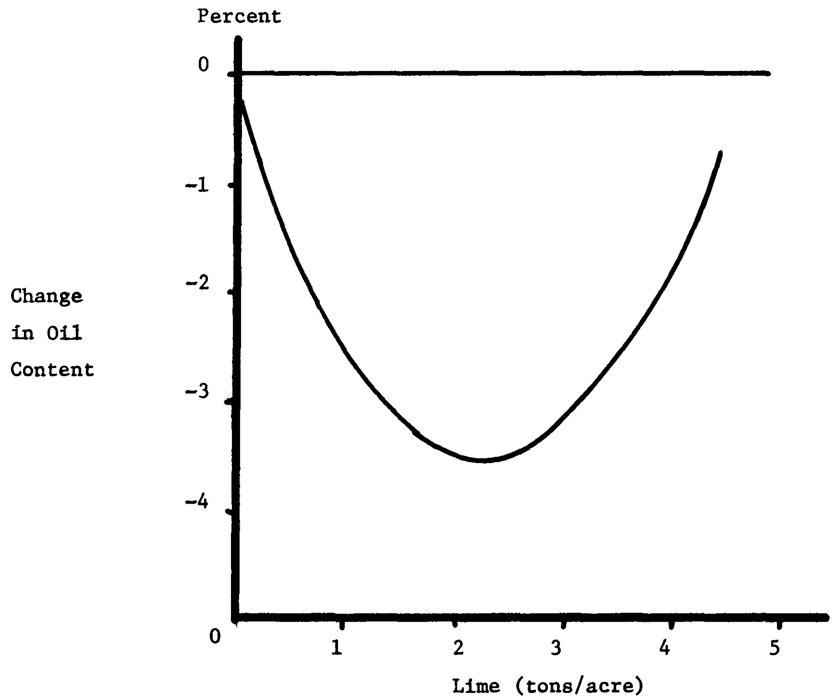

Figure 2. Effect of lime on oil content of soybeans

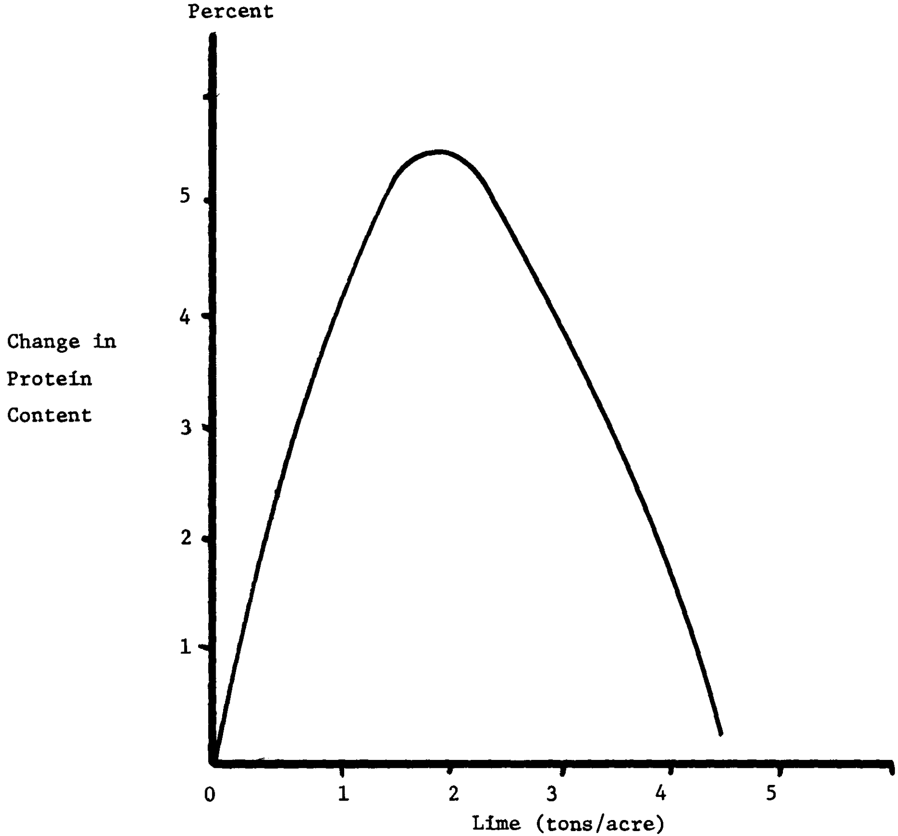

Figure 3. Effect of Lime on protein content of soybeans

protein and oil content occurred at slightly over 2 tons of lime per acre.

Where nitrogen (N), phosphorus (P), potassium (K) and trace minerals (copper, manganese, baron, zinc) were treatments, analysis of individual locations failed to indicate any relationship between these treatments and oil and protein content. However, analysis of the pooled data on fertilizer treatments across locations showed quite clearly that both nitrogen and potash applications increased protein content with very little, if any, effect on oil content. The estimated relationships for nitrogen and potash are shown in Figure 4.

Planting Practices

The pooled data failed to show any effect of seeding rate, seed size, or row width on oil or protein content. There was evidence that delayed seeding dates reduced protein content at the rate of about .016 percent protein per day and increased oil content at the rate of about .008 percent oil per day of delay. Thus, a delay in planting from mid-May to late June will reduce protein content by about 0.72 percent and increase oil content by about 0.36 percent. Furthermore, there was evidence from one location that increasing the spacing within the row tended to decrease protein content and increase oil content.

There was slight evidence at one location that preemergence and postemergence herbicide treatments banded and broadcast might have affected oil and protein content, but there was no evidence at three other locations. Therefore, herbicides do not appear to be an important factor in determining oil and protein content.

Seed treatments were considered at four locations, and the data indicated that treatment with molybdenum increased protein content by about 1.85 percent and decreased oil content by about 0.93 percent relative to no treatment. Other combinations of seed treatments were applied, with the results shown in Table 3.

Soil Conditions

Soil test measurements were made at 18 Coastal Plain locations and 2 Piedmont locations. Measurements included pH (taken after

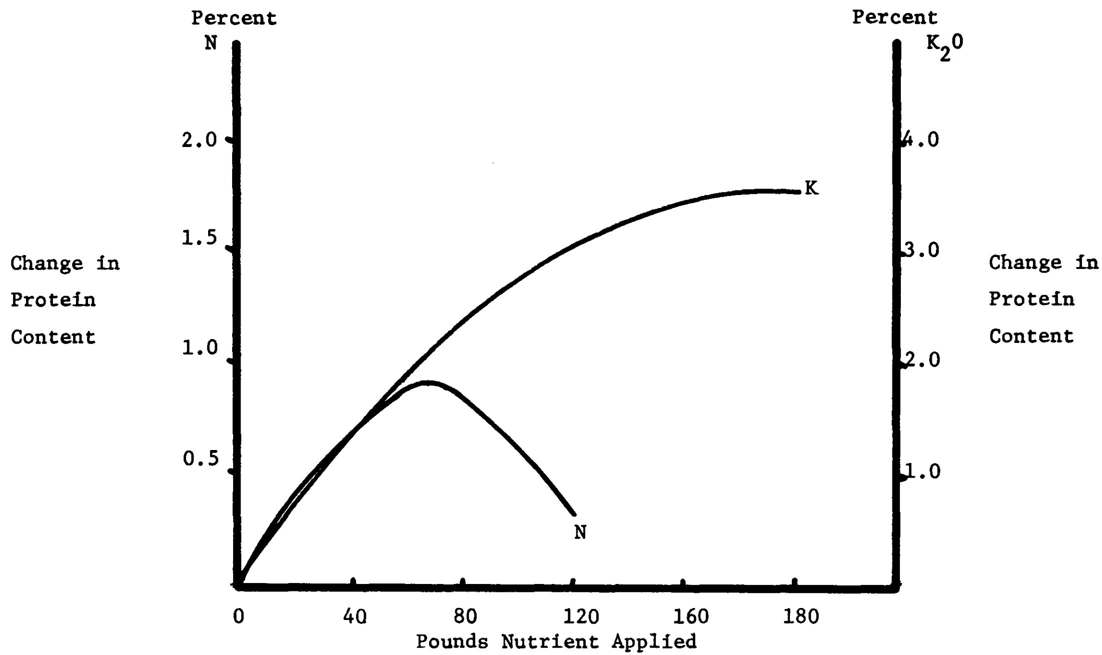

Figure 4. Effects of nitrogen and potash on protein content of soybeans

Table 3 Effects of seed treatments on average oil and protein content at four locations

Treatment	Estimated Effect: Oil Content	Estimated Effect: Protein Content
No Treatment	.61	- .38
Urbana Inoculant	- .07	.52*
Urbana-Molybdenum	- .44	.30
Urbana Inoculant and Molybdenum	- .42	.75*
Kalo-Noctin	- .44	.47*
Kalo-Molynoctin	- .77*	- .75
Kalo-Rhizobium	- .39	.17
Thiran-Micronutrients	.59	- .33
Dormal	- .02	- .35
Mag-Car	.51	- .38
Vitavax	1.01**	-1.05**
Cobalt in Solution and Molybdenum and Inoculant	- .14	- .33
Molybdenum	- .93*	1.85*

*Significantly different from average at the 5 percent level.

**Significantly different from average at the 1 percent level.

season where lime was applied and at the beginning of the season elsewhere), and tests for phosphorus, potassium, calcium, magnesium, manganese, and organic matter. While most of these measurements were found to be correlated with yield, oil and protein content were affected only by soil phosphorus and soil calcium. Soil phosphorus was related to low oil content (-0.065 percent oil per one part per million of P in the soil) and high protein content (+0.027 percent protein per one part per million of P in the soil). Calcium was related to higher protein content (+0.035 percent protein per one part per million of Ca in the soil).

Economic Choices

These experiments have shown that soybean varieties, lime, fertilizer levels, and seeding date all have an affect on oil content or protein content or both. The question arises whether farmers should be advised to adopt particular practices if farmers were, in fact, paid for the oil and protein produced, rather than the quantity of beans. The average yield per acre of the plots in these experiments was 43 bushels, or about 2,244 pounds of dry matter, assuming an average dry matter content of 87 percent. At a protein price of 16¢ per pound (corresponding to $140 per ton of 44 percent protein meal), a 1 percent increase in protein content would be worth an additional $3.59 per acre. For an oil price of 20¢ per pound, a 1 percent increase in oil content would be worth an additional $4.48 per acre. With yields lower than 43 bushels per acre, the value of additional protein and oil content would of course be proportionately lower.

In the analysis of factors affecting yield, it was assumed that the effects of the various factors are independent of one another - implying, for instance, that the estimated increases in protein content from applying lime, nitrogen and potash may all be achieved simultaneously with the above-average protein content of, say, the Hutton variety. The economic analysis of producer choices was predicted on this assumption, as well. However, it is probably not true that the effects of all practices can be realized simultaneously. The study was not large enough to resolve this question.

Varieties

Among the higher protein and oil yielding varieties, higher protein content can be achieved only at the expense of lower oil content, at a trade-off of about one-to-one.

However, quite a different picture emerges when estimated bushel yield differences as well as oil and protein content are considered. Estimated production per acre of pounds of protein and pounds of oil are plotted in Figure 5. Several varieties with average protein and oil content, such as N70-2151, Essex, FFR666, Davis and Lee, produce greater totals of oil and protein per acre (and therefore greater revenue per acre) than do varieties with extremes in protein and oil content, such as Hutton and Ransom. The dashed lines in Figure 5 show combinations of oil and protein production which would result in receipts of \$220-\$270 per acre, if beans were sold on the basis of 16¢ per pound of protein and 20¢ per pound of oil.

Fertilizer Practices

The application of nitrigen and potash was found to increase the protein content of soybean, without significantly affecting either oil content or bushel yield. Given the response of the soybean plant to nitrogen, the greatest return of protein to nitrogen would occur with the application of about 40 lbs. of N per acre. But even at this level, the cost of the fertilizer (\$8.00 per acre of \$0.20 per pound of N) greatly exceeds the increased value of the crop (\$2.76 for an increase of 0.77 percent at a yield of 43 bushels per acre). Similarly, the best level of potash, 120 lbs. per acre, is predicted to increase protein content by 3.3 percent, but with a 43 bushel yield the value of the extra protein is but \$11.78 compared to a cost of \$16.80 for the potash (at 14¢ per pound of K_2O). Thus it appears that even though N and K_2O increase protein content of beans, the value of the increased protein is less than the cost of the fertilizer applied. Furthermore, neither nitrogen nor potash increased yields in these experiments.

Lime applications on acid soils are estimated to increase both bushel yields and protein levels. Two tons of lime are predicted to increase protein content by 5 percent, decrease oil content by 3.5

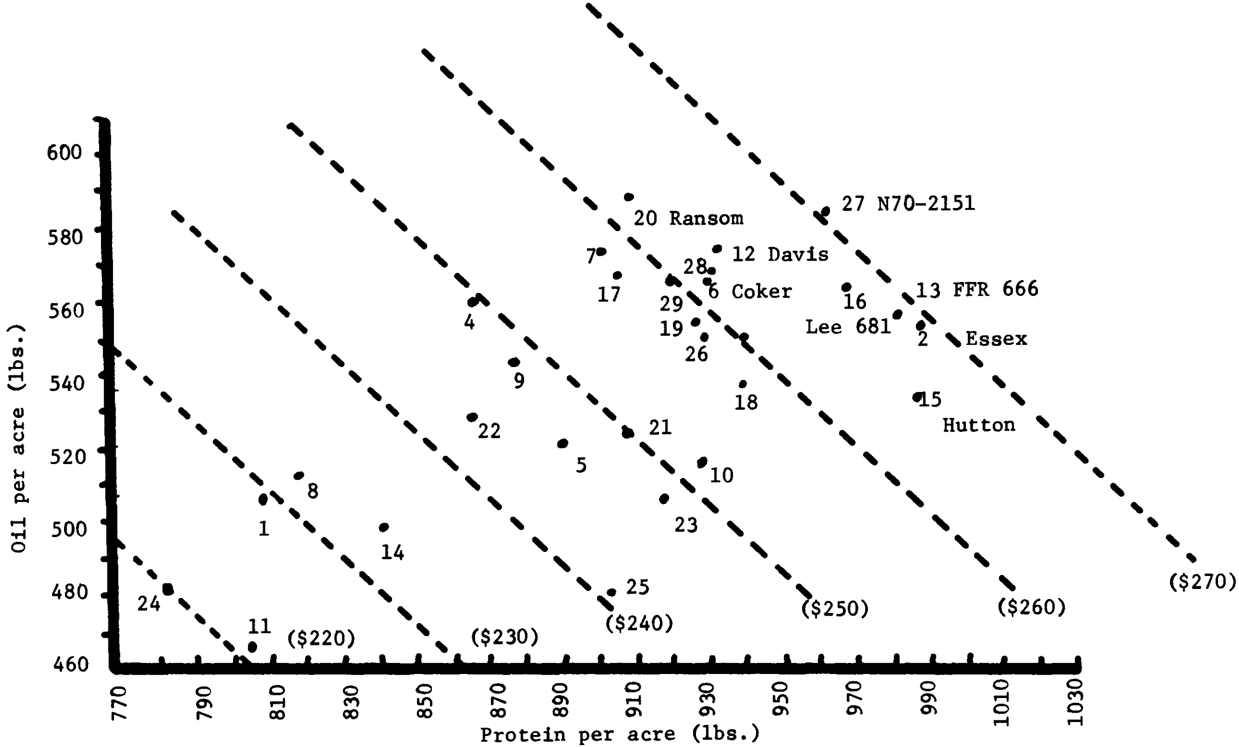

Figure 5. Estimated pounds of protein and oil per acre produced by various varieties on cooperating farmer plots (numbered as in Table 2)

percent, and increase yields by 7 bushels per acre. At a yield of 43 bushels (after liming), the value of the increase inpprotein is $17.85 while the value of the oil decrease is $15.53, for a net gain of $2.32. This would not be sufficient to justify the cost of two tons of lime (approximately $28 worth), but the extra 7 bushels yield would increase the returns by an additional $40.60 (again for oil at 20¢ per pound and protein at 16¢ per pound).

Planting Date

It is estimated that protein content decreased by about 0.016 percent per day of planting delay, while oil content increases by only half this amount. Clearly this would be an undesirable tradeoff for the producer, unless yields increased significantly with the delay.

Summary

A study was made to determine what factors affect the oil and protein content of soybeans grown in North Carolina. The study sample consisted of nearly 1100 observations taken from 33 experimental plots in Eastern and Piedmont North Carolina during 1973.

In this study it was found that soybean varieties, soil characteristics and cultural practices do have an effect on the oil and protein content of soybeans. It was also established that there is not a significant difference in the average protein and oil content of beans between regions within the state.

There are wide variations in oil and protein content among soybean varieties grown within the state. While there are varieties with significantly higher-than-average protein or oil content, both cannot be obtained simultaneously. Furthermore, some varieties with near-average protein and oil content (such as Lee, Davis and N70-2151) will produce a greater yield per acre than will the high oil or high protein varieties.

It was found that liming acid soils according to soil test suggestions increased both protein levels and yields. Two tons of lime per acre increased protein content by 5 percent, decreased oil content by 3.5 percent and increased yields by 7 bushels.

Nitrogen and potash applications increase protein content without significantly affecting either oil content or yields. Based on the response of protein to nitrogen, the greatest return to nitrogen occurs at 40 lbs. of N per acre. Similarly, the greatest return of protein to potash occurs at 120 lbs. per acre. However, it was found that these responses are not sufficient to offset the current costs of the practices.

Treating seed with molybdenum will increase protein but reduce oil content of beans. Delaying planting beyond mid-May decreases protein content by about 0.016 percent per day and increases oil content an average 0.008 percent per day.

A number of factors such as seeding rate, seed size, row width and herbicide treatment were found not to be associated with oil and protein content. However, liming, selecting the variety to be planted, choosing the proper planting date, and treating the seeds with molybdenum before planting may provide producers with opportunities to increase protein content of soybeans as well as yields in North Carolina.

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